

What is claimed is:

1. An optical element having a surface treatment comprising a polyfluoropolyether compound having at least one polar group or polar group-containing organic radical.

2. The optical element of claim 1 wherein the polyfluoropolyether compound has the general formula  $R_f-[X]_y$  wherein  $R_f$  is a monovalent or divalent perfluoropolyether group, X is a polar group or polar group-containing organic radical, and y ranges from 1 to 2.

3. The optical element of claim 2 wherein  $R_f$  comprises one or more repeating units selected from the group comprising  $-(C_nF_{2n})-$ ,  $-(C_nF_{2n}O)-$ ,  $-(CF(Z))-$ ,  $-(CF(Z)O)-$ ,  $-(CF(Z)C_nF_{2n}O)-$ ,  $-(C_nF_{2n}CF(Z)O)-$ ,  $-(CF_2CF(Z)O)-$ , and combinations thereof; wherein the average n value ranges from 1 to 4 and Z is a perfluoroalkyl group, an oxygen-substituted perfluoroalkyl group, a perfluoroalkoxy group, or an oxygen-substituted perfluoroalkoxy group having 1 to about 4 carbon atoms and 1 to about 4 oxygen atoms.

4. The optical element of claim 2 wherein X is selected from the group comprising carboxylic acid, sulfonic acid, phosphonic acid, carboxylate salt, sulfonate, phosphonate, phosphate esters, ammonium salts, amine, amide, alkyl amide, alkyl aryl amide, imide, sulfonamide, hydroxymethyl, thiol, ester, silane, polyoxyalkylene, organic radicals substituted with one or more of said polar groups, and mixtures thereof.

5. The optical element of claim 2 wherein the polyfluoropolyether compound is selected from the group comprising the general formulas:

- i)  $X-CF_2O[(CF_2O)_m(C_2F_4O)_p]CF_2-X$ ;
- ii)  $C_3F_7O(CF(CF_3)C_2O)_pCF(CF_3)-X$ ; and
- iii)  $X-CF_2O(C_2F_4O)_mCF_2-X$ ;

wherein m and p each independently range from 0 to 50, with the proviso that m and p are not both 0 and X is a polar group or polar group-containing organic radical selected from the group comprising  $CONH(CH_2)_3Si(OMe)_3$ ,  $CONH(R)$  wherein R is an alkyl radical

having 1 to 8 carbon atoms, CONHCH<sub>2</sub>CH<sub>2</sub>Ph, CO<sub>2</sub>NH<sub>4</sub>, CH<sub>2</sub>NH<sub>2</sub>, CO<sub>2</sub>H, CH<sub>2</sub>OH, CO<sub>2</sub>CH<sub>3</sub> and combinations thereof.

6. The optical element of claim 2 wherein the polyfluoropolyether compound has the general formula:

- i)  $X-(CF_2O(CF_2O)_m(C_2F_4O)_pCF_2)-X$  wherein X is  
CONH(CH<sub>2</sub>)<sub>3</sub>Si(OMe)<sub>3</sub>; CO<sub>2</sub>H, CO<sub>2</sub>NH<sub>4</sub>, and mixtures thereof;
- ii)  $C_3F_7O(CF(CF_3)CF_2O)_pCF(CF_3)-X$  wherein X is CO<sub>2</sub>H, CO<sub>2</sub>NH<sub>4</sub> and mixtures thereof;

wherein m ranges from 0 to 50 and p ranges from 0 to 50, with the proviso that m and p are not both 0.

7. The optical element of claim 1 wherein the polyfluoropolyether compound has the general formula  $[R_f-X]_n-L_c$  or  $[R_f-X-L-X]_n$  wherein R<sub>f</sub> is a monocovalent or dicovalent perfluoropolyether group, X is a dicovalent polar group or polar group-containing organic radical, n ranges from 2 to 20, L<sub>c</sub> is a polycovalent core linkage, and L is a linkage derived from a comonomer.

8. The optical element of claim 1 wherein the number average molecular weight of the polyfluoropolyether compound ranges from about 400 to about 10,000 g/mole.

9. The optical element of claim 8 wherein the number average molecular weight of the polyfluoropolyether compound is greater than about 1000 g/mole.

10. The optical element of claim 8 wherein the number average molecular weight of the polyfluoropolyether compound is greater than about 2000 g/mole.

11. The optical element of claim 8 wherein the number average molecular weight is less than about 8,000 g/mole.

12. The optical element of claim 1 wherein the percent float in heptane is at least about 90%.

13. An optical element having a surface treatment comprising a fluorochemical compound at a concentration of less than about 100 ppm wherein the percent float in heptane is at least about 90%.

14. An optical element having a surface treatment comprising a fluorochemical compound having the general formula  $(C_nF_{2n+1})-X$  wherein  $n$  is about 4 and  $X$  is a polar group or polar group-containing organic radical selected from the group comprising sulfonic acids and salts thereof; sulfonamides, sulfonimides and salts thereof; amides, silanes, and mixtures thereof.

15. An optical element having a surface treatment comprising a fluorochemical compound having the general formula  $(C_nF_{2n+1})-X$  wherein  $n$  is about 4 and  $X$  is a polar group or polar group-containing organic radical; and wherein said compound is free of heavy metals and transition metals.

16. A method of coating optical elements comprising the steps of:

- a) providing an aqueous surface treatment according to claim 1;
- b) coating optical elements with said composition; and
- c) drying said composition.

17. A method of coating optical elements comprising the steps of:

- b) providing an aqueous surface treatment according to claim 14;
- b) coating optical elements with said composition; and
- d) drying said composition.

18. A method of coating optical elements comprising the steps of:

- c) providing an aqueous surface treatment according to claim 15;
- b) coating optical elements with said composition; and
- e) drying said composition.

19. The method of claim 16 wherein said aqueous composition comprises up to about 30 wt-% of a cosolvent with respect to the total weight of the solution.

20. The method of claim 17 wherein said aqueous composition comprises up to about 30 wt-% of a cosolvent with respect to the total weight of the solution.

21. The method of claim 18 wherein said aqueous composition comprises up to about 30 wt-% of a cosolvent with respect to the total weight of the solution.

22. A pavement marking comprising a liquid binder and a multitude of the optical elements of claim 1.

23. A pavement marking comprising a liquid binder and a multitude of the optical elements of claim 14.

24. A pavement marking comprising a liquid binder and a multitude of the optical elements of claim 15.

25. The pavement marking of claim 22 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

26. The pavement marking of claim 23 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

27. The pavement marking of claim 24 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

28. A reflective sheeting comprising:

- a) a top coat layer having an exposed surface;
- b) a binder layer disposed on the exposed surface of the top coat layer;
- c) a multitude of the optical elements of claim 1 disposed in the binder layer;

- d) a space coat layer disposed on the binder layer; and
- e) a reflective layer disposed on the space coat layer.

29. A reflective sheeting comprising:

- a) a top coat layer having an exposed surface;
- b) a binder layer disposed on the exposed surface of the top coat layer;
- c) a multitude of the optical elements of claim 14 disposed in the binder layer;
- d) a space coat layer disposed on the binder layer; and
- e) a reflective layer disposed on the space coat layer.

30. A reflective sheeting comprising:

- a) a top coat layer having an exposed surface;
- b) a binder layer disposed on the exposed surface of the top coat layer;
- c) a multitude of the optical elements of claim 15 disposed in the binder layer;
- d) a space coat layer disposed on the binder layer; and
- e) a reflective layer disposed on the space coat layer.

31. The reflective sheeting of claim 28 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

32. The reflective sheeting of claim 29 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

33. The reflective sheeting of claim 30 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

34. A rear projection screen comprising a transparent substrate and the optical elements of claim 1 embedded in an opaque binder matrix and wherein said optical elements are in contact with the transparent substrate.

35. A rear projection screen comprising a transparent substrate and the optical elements of claim 14 embedded in an opaque binder matrix and wherein said optical elements are in contact with the transparent substrate.

5 36. A rear projection screen comprising a transparent substrate and the optical elements of claim 15 embedded in an opaque binder matrix and wherein said optical elements are in contact with the transparent substrate.

10 37. The reflective sheeting of claim 34 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

38. The reflective sheeting of claim 35 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.

15 39. The reflective sheeting of claim 36 wherein the optical elements are embedded in the binder at a depth of about 40-70% of their diameters.